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SOME OBSERVATIONS ON DOMESTIC SHEEP AND WILDLIFE RELATIONSHIPS IN Q-FEVER [1]

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Abstract

A cycle of prevalence of Q-fever antibodies in sheep is confirmed, and possible relationships between sheep, wild mammals and birds in the ecology of Q-fever are exhibited. Carnivores and carrion-eaters, including coyotes *(Canis latrans)*, turkey vultures *(Cathartes aura)*, grey foxes *(Urocyon cinereoargenteus)*, and hawks [Red-tailed hawk *(Buteo borealis)* and Sparrow hawk *(Falco sparverius)*] have serological evidence of Q-fever indicating exposure relative to their food habits. Herbivorous mammals and birds have evidence of Q-fever exposure relative to their relationship with sheep: species that share the same pastures as the sheep have a higher percentage with Q-fever antibodies than species inhabiting the protective underbrush or species that are more independent of the activities of livestock. A detailed study of 5 representative wildlife species, including the deer mouse *(Peromyscus maniculatus)*, black - tailed jackrabbit *(Lepus californicus)*, Columbian black-tailed deer *(Odocoileus hemionus columbianus)*, ground squirrel *(Citellus beecheyi)*, and the common red-wing blackbird *(Agelaius phoeniceus)* indicated that the blackbird has a peak prevalence of antibodies before that of sheep, the black-tailed jackrabbit and the ground squirrel seem to parallel sheep in cyclic responses, and the peak prevalence of Q-fever antibodies in the deer mouse occurs after the peak response in sheep. Deer responses appear to be unrelated to sheep responses.

Introduction

Epidemiologic studies have confirmed that Q-fever infection in man is usually acquired through exposure to infected domestic livestock. *Coxiella burnetii*, the rickettsial causative agent of Q-fever, is released into the environment in large numbers via the milk, colostrum, placental tissues, birth fluids and feces of cattle, sheep and goats.[1,6,7,17] Man, as well as animals, usually becomes infected through the respiratory route by the inhalation of aerosols or dust contaminated with this highly resistant organism.[5,10]

In nature, *C. burnetii* has been reported to survive in a wildlife cycle independent of that of domestic animals, possibly by means of tick transmission. In this country *C. burnetii* was isolated from three species of rodents and from one species of tick collected in the Great

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Salt Lake Desert in Utah.[14] A five-year continuation of the Utah study resulted in serologic evidence of Q-fever in 19 species of wildlife and the isolation of *C. burnetii* from the tissues of 91 animals and 3 ectoparasites.[16] Incidental to studies of Rocky Mountain Spotted fever rickettsiae in the Bitterroot Valley of Western Montana, *C. burnetii* was isolated from a wood rat, 2 golden-mantled ground squirrels and a chipmunk.[4]

Little attention has been given in this country to the importance of birds in the chain of infection. In the Utah study 36 species of wild birds were tested, with no serologic evidence of Q-fever.[16] However, European investigators have reported complement-fixing antibodies in a large number of pigeons and isolated *C. burnetii* from the kidneys of a pigeon from an endemic Q-fever area.[2,3]

In Czechoslovakia, studies on domestic and wild birds gave serologic evidence of Q-fever in chickens, turkeys, ducks, geese, pigeons, and wild birds. The proportion of serologically positive birds varied inversely with the distance they lived from infected farms.[15] In Russia, human cases of Q-fever were traced to the eating of raw eggs from infected chickens.[18] Experimental studies have shown that chickens are able to excrete *C. burnetii* in the feces up to 40 days after infection.[15]

Q-fever has been extensively studied in domestic livestock and to some extent in wild mammals and birds, but little has been said about the relationships and interplay of Q-fever infection between these three groups. In recent investigations into the ecology of Q-fever in a natural environment, sheep, wild mammals and birds sharing the same habitat were studied. The results of these investigations will be published in detail; however, selected observations on possible relationships between sheep and wildlife are included in this preliminary report.

Materials and Methods

A study of the ecology of Q-fever was conducted at the University of California Field Station at Hopland in 1965 and 1966. The area of the station is approximately 5000 acres, ranging from 500 to 3,000 feet in elevation in the Coastal Mountain Range. The major land use involves range management, animal husbandry and wildlife investigations. A breeding flock of approximately 1200 sheep and a small herd of cattle share the same environment as deer, rabbits, squirrels and numerous other native wildlife species.

Sampling

Serum samples were collected from sheep, wild mammals, and wild birds on the Hopland station and from wild birds on a dairy premise approximately 10 miles north of the station. Serum samples from mammals were tested for the presence of antibodies to *C. burnetii* using the microtechnique[12] of the complement fixation test (CFT).[9] The capillary agglutination test (CAT)[11] was used for bird sera.[13] The Nine Mile strain of antigen (Lederle) was used in the CFT to test mammalian serum and the capillary agglutination test antigen obtained from C.D.C.* A positive reaction of a 1:8 serum dilution in the CFT or an agglutination reaction in a 1:2 final dilution of bird serum was taken as evidence of antibodies to Q-fever.

Serum samples were collected from 150 to 200 ewes 5 times during 1965: January, March, May, September and December. The cycle observed in graphing results from these samples was projected through 1966 (Figs. 1-5). In 1965 blood samples were collected from lambs on the day of birth (January), and from the same lambs again in March, May, September, November and December, 1965, and January and March, 1966. A group of lambs born in 1966 was bled in January, March, May, September and

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December, 1966, and in January and February, 1967. In 1965 the size of the sample of lambs ranged from 260 at birth to 130 in December. The size of the group of lambs born in 1966 declined from 373 at birth to 104 in December. The decline in number of lambs bled on successive dates is due to the sale of spring lambs, particularly of males, and to natural mortality.

Results and Discussion

Seasonal variation

Our analysis of sheep sera containing specific antibodies indicated an annual cycle in the prevalence of Q-fever antibodies (Fig. 1). This response may be related to parturation, sheep to sheep contact (breeding), weather conditions or some unknown factors. We also observed seasonal variations in the percentage of serologically positive wildlife species. It was important to understand whether the sheep and wildlife were responding similarly to a common source of exposure, or if one group was infecting the others. The possible annual cycles of selected wildlife species including *Peromyscus maniculatus,* black - tailed jackrabbit, deer, ground squirrel, and red-wing blackbirds were graphed and compared with the sheep cycle (Figs. 1-5).

Peromyscus maniculatus had a peak response (prevalence of Q-fever antibodies) during May-June, and lowest response during August-September (Fig. 1). The black-tailed jackrabbit exhibited peak response in February-March of both years, followed by a rapid decline to low response in April-June (Fig. 2). The prevalence of Q-fever antibodies in the black-tailed deer appeared to be unrelated to response in sheep, possibly due to small samples per month with resultant wide confidence limits (Fig. 3). The ground squirrel had a low response during most of the 2-year period of study. Based on an examination of the confidence intervals, the relative peak of response in ground squirrels could occur any time between November and May, with a relatively low level of response during July-August (Fig. 4). Comparison of Figs. 1-4 with Fig. 5 indicates that blackbirds may be exposed to sources of Q-fever in their flight range other than the local sheep population, for they appear to have a peak response before the peak response occurs in sheep.

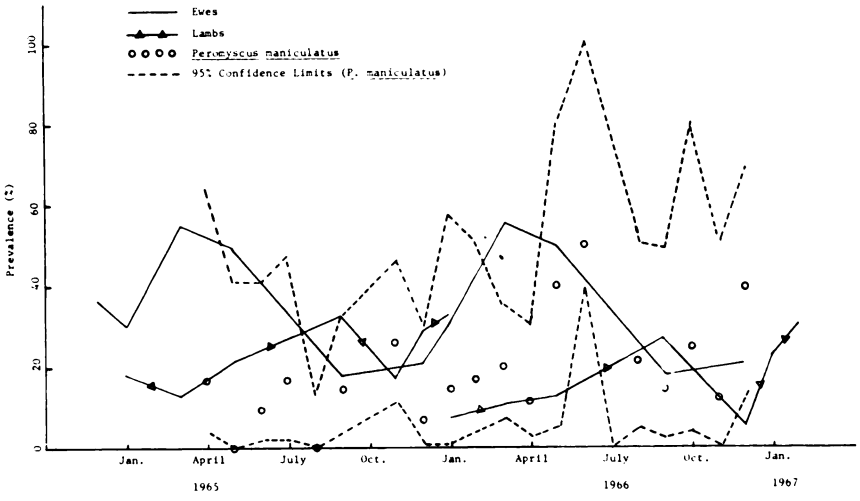

FIGURE 1. *Prevalence of Q-fever antibodies in the deer mouse* (Peromyscus maniculatus), *domestic ewes and lambs during 1965-66.*

In the Czechoslovakian study of wild birds[15] the highest prevalence (15.8%) of Q-fever antibodies was found in birds inhabiting infected farm communities, while only 4.3% of the birds collected from the surrounding vicinity were positive. Species of birds collected in the same area but entirely independent of man's activities were only 1.8% positive. In the Hopland study area several species of mammals and birds share the same habitat, have similar food habits or in some manner may share a common exposure to Q-fever. To illustrate possible relationships between the domestic animals and wild mammals and birds, the percent of selected species of mammals and birds that were serologically positive for Q-fever were arranged monotonically (Figure 6). The proportion of sheep with Q-fever antibodies ranged from 18% to 55% with a midrange of 36%. Coyotes and turkey vultures had the highest percent positive suggesting a relationship between the carnivores (or carrion eaters) and sheep, for coyotes are known to kill many sheep on the station and the coyotes and turkey vultures feed on the carcasses. *C. burnetii* was isolated from the placental tissues and spleens of deer and small mammals in the area.[8] Infected tissues from these animals are a likely source of exposure for carnivores and carrion eaters. Grey foxes also had a high percent of positives and while these animals usually depend on smaller birds and mammals for food, they may also feed on infected sheep carcasses. However, the close similarity between the percent positives among brush rabbits and grey foxes indicates that the rabbits may be a major food source for foxes or that these two species may share a common habitat relative to exposure to *C. burnetii*. The species of wild mammals and birds in the 18 to 55% positive category (Fig. 6) share the same pastures, and as noted above, the seasonal variations of antibody prevalence among black-tailed jackrabbits and ground squirrels are similar to sheep. (Figs. 2, 4).

Only small samples of hawks were obtainable so several genera of raptors were placed into the same category to obtain the proportion for "hawks" in Figure 6. The percent of positive hawks was in the range of small rodents which may indicate another source of infection related to the food chain.

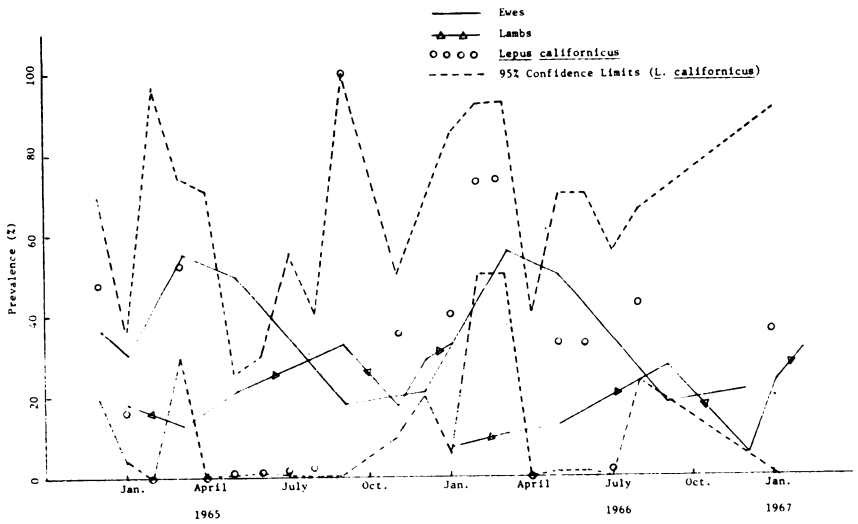

FIGURE 2. *Prevalence of Q-fever antibodies in the black-tailed hare* (Lepus californicus), *domestic ewes and lambs during 1965-66.*

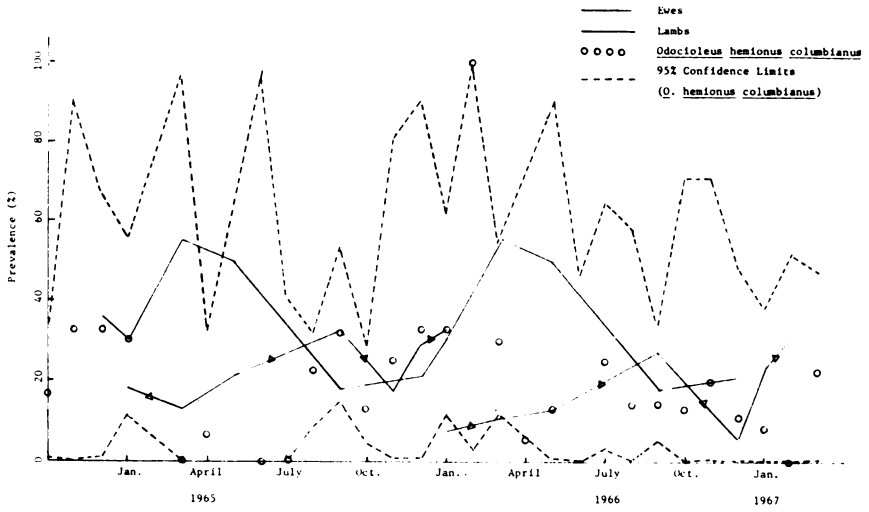

FIGURE 3. *Prevalence of Q-fever antibodies in the black-tailed deer* (Odocoileus hemionus columbianus), *domestic ewes and lambs during 1965-66.*

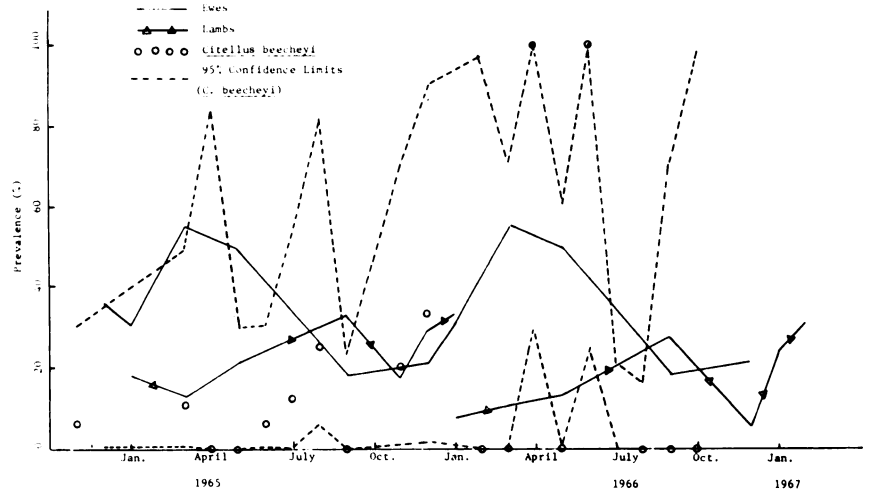

FIGURE 4. *Prevalence of Q-fever antibodies in the ground squirrel* (Citellus beecheyi), *domestic ewes and lambs during 1965-66.*

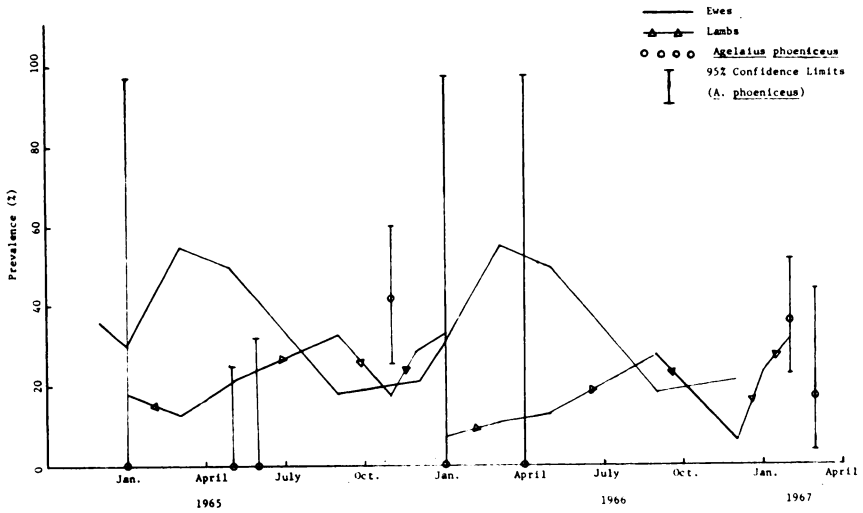

FIGURE 5. *Prevalence of Q-fever antibodies in the common red-wing* (Agelaius phoeniceus), *domestic ewes and lamsb during 1965-66.*

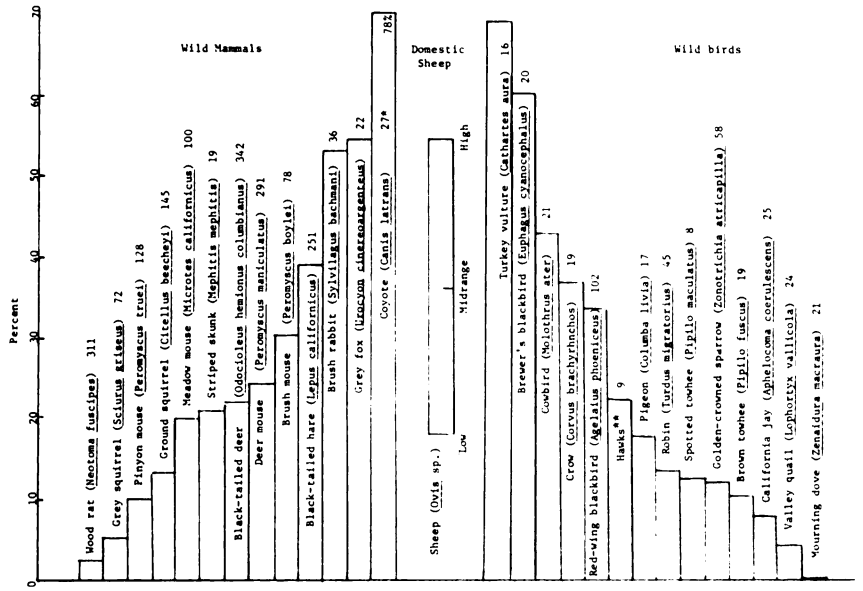

FIGURE 6. *The percent of sheep and wildlife serologically positive for Q-fever in the Hopland California area during 1965 and 1966. *Number of animals collected. **3 Red-tailed hawks* (Buteo borealis), *3 Sharp-shinned hawks* (Accipiter velox), *2 Cooper's hawks* (Accipiter cooperi) *and 1 Sparrow hawk* (Falco sparverius).

Isolations of *C. burnetii* were made from the tissues of deer showing that these animals may harbor this rickettsia. However, it is not well understood whether they reflect the same infection as the domestic animals or are a primary source of *C. burnetii* in a wildlife cycle.

Wood rats *(Neotoma fuscipes)* were among the least infected animals, and California Valley quail *(Lophortyx vallicola)* and mourning doves *(Zenaidura macraura)* among the least infected birds. Most of those species with approximately 10% or less positives occupy the more protected bushy areas relatively inaccessible to sheep or in some manner have less contact with domestic livestock.

Similarities and common factors in the complex interactions of Q-fever between domestic animals and wild mammals and birds are evident, but more exact relationships have yet to be determined. Domestic animals may be the primary source of infection in this area and wild mammals and birds reflect their exposure to *C. burnetii* depending on how closely they are associated with the domestic species. On the other hand, *C. burnetii* appears to be capable of surviving in wildlife independently of domestic livestock. However, in areas occupied by both livestock and wildlife there is an interaction among domestic animals and wildlife that involves food habits, a common range, weather conditions and possibly ectoparasites.

Further investigation is needed to fully understand the complex ecology of *C. burnetii.*

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